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Fire Testing of Roof-Mounted Solar Collectors by ASTM E 108

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
Center for Fire Research and
Center for Building Technology

August 1981

Prepared for:

Department of Energy
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William D. Walton and David Waksman

ABSTRACT

A study was undertaken to investigate the use of ASTM E 108 (NFPA 256, UL 790), Fire Tests of Roof Coverings, for testing roof-mounted solar energy collectors. The ASTM E 108 test method is commonly referenced in building codes as the procedure for determining the fire characteristics of roof coverings. To date, no data have been available regarding the influence of solar collectors on the fire characteristics of roof coverings or on collectors used as roof coverings. This study focused primarily on class C intermittent flame, spread of flame, and burning brand tests, although several class A and B burning brand tests were conducted. The collectors studied were commercially available and constructed with a broad variety of glazing, casing, and insulation materials representative of those commonly in use. The collectors were tested on sloped, asphalt shingled, roofs with three types of mountings: integrally as the roof, directly on the roof covering, and on standoffs above the roof covering. Data are presented showing the results of the testing conducted. An evaluation of the testing procedures as they apply to roof-mounted solar collectors is given.

Key Words: Fire tests; roofing fire characteristics; roofing fire tests; solar collectors

1. INTRODUCTION

ASTM E 108 "Fire Tests of Roof Coverings" [1][1], also known as NFPA 256 [2] and UL 790 [3], is a commonly used test procedure to determine the fire characteristics of roof coverings when exposed to fires originating outside the building on which they are installed. Provisions based on this test procedure have been incorporated into building codes used in many jurisdictions. As the use of solar collectors has become more widespread, a number of codes and standards have added statements to the effect that solar collectors shall not reduce the required performance of the roof covering materials in a fire as determined by ASTM E 108 [4,5].

[1] Numbers in brackets refer to the references listed at the end of this publication.

The fire testing described in this paper was conducted: (1) to evaluate the use of ASTM E 108 as a means for determining the influence of roof-mounted solar collectors on the fire characteristics of roof coverings, (2) to determine modifications in the basic testing procedure that may be required to make it applicable to roof-mounted solar collectors, and (3) to determine the influence that flat plate solar collectors constructed of various materials may have on the fire characteristics of roof coverings. No attempt was made to rate or certify the collectors tested. This study does not address other fire-related features of solar energy systems not addressed by ASTM E 108; e.g., the potential for self-ignition of solar collectors under either operating or stagnation conditions, and the fire resistance of roofing assemblies with solar collectors when exposed to interior fires.

This work was performed under the technical direction of the National Bureau of Standards and utilized the baseline fire testing procedures outlined in NBSIR 78-1305 A [6]. It was undertaken as part of a U. S. Department of Energy sponsored program to develop and evaluate testing procedures that can be used to assess the reliability/durability and safety of solar collectors. The testing was carried out at two different testing laboratories: Underwriters Laboratories, Inc. and Approved Engineering Testing Laboratories[2].

2. EXPERIMENTAL PROGRAM

Test specimens were selected to be representative of the broad range of materials and design configurations used in flat plate solar collectors intended for solar heating and cooling applications. A cross section of a typical flat plate collector is shown in Figure 1. Four types of configurations are commonly used for solar collectors mounted on sloped roofs. These include: (1) integral mounting as roofing elements, (2) direct surface mounting on top of the roofing material, (3) on standoffs parallel to the roofing surface, and (4) on racks at an angle to the roofing surface. Diagrams of the mounting configurations are shown in Figure 2. The materials used in the solar collectors selected for evaluation and their dimensions are summarized in Table 1. These materials include aluminum, steel, wood, glass, fiberglass reinforced plastic (FRP), etc. The types of tests conducted, the mounting configurations, and the roof slopes used are summarized in Table 2. Major emphasis was placed on glazing, casing, and insulation materials and on the types of mounting configurations used. Unless otherwise noted, collectors on standoffs were mounted on noncombustible spacers located at each corner. Only one angular rack-mounted solar collector was tested. All collectors were tested without heat transfer fluid.

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[2] Reference to the testing laboratories participating in the program is made solely for informational purposes. Such identification does not imply recommendation or endorsement by the National Bureau of Standards.

Wooden test decks covered with shingles representative of the median of class C were used for purposes of equipment calibration and for the mounting of collectors, where required. Typical class C asphalt impregnated organic-felt shingles from the same lot were used for all tests. Except as noted, in all tests where a roof deck was used, the collector was mounted one foot (30 cm) back from the leading edge of the deck which was closest to the burner. The standard 12 $\pm$ 0.5 mph (5.3 $\pm$ 0.2 m/s) wind condition specified in ASTM E 108 was used for all tests, with the exception of tests Nos. 22 and 23 which were conducted without wind to determine the influence of wind. A roof slope of 5 in 12 (23°) was used, unless otherwise indicated on Table 2.

The testing focused primarily on the class C intermittent flame, spread of flame, and burning brand test conditions described in ASTM E 108, although several class A and B burning brand tests were also conducted. A diagram of the test apparatus is shown in Figure 3.

According to ASTM E 108, the class A tests represent a severe exposure; class B, a moderate exposure; and, class C, a light exposure. The following is a summary of the test conditions and conditions of classification given in ASTM E 108. The test decks for the intermittent flame and burning brand tests are 3 1/3 feet (1.0 m) wide and 4 1/3 feet (1.3 m) long. The deck for the spread of flame test is 3 1/3 feet (1.0 m) wide and 13 feet (4.0 m) long.

As shown in Figure 4, Class A and B brands are constructed of nominal 1 x 1-inch (25 x 25-mm) Douglas fir wood strips with a finished size for class A brands of 12 x 12 x 2 11/32 inches (305 x 305 x 59.5 mm) and class B brands of 6 x 6 x 2 11/32 inches (152 x 152 x 59.5 mm). Class C brands consist of a piece of white pine wood 1 1/2 x 1 1/2 x 25/32 inches (38 x 38 x 19.8 mm) with saw kerfs in the top and bottom faces. The class A burning brand test utilizes 1 brand; the class B test, 2 brands; and, the class C test, 25 brands. For all classes of the burning brand test, the brands are ignited before they are placed on the roof at the location considered most vulnerable. The test is continued until there is no evidence of flame, glow, or smoke from either the brands or the test deck. In this test program, brands were placed on the collector covers and, for collectors mounted on standoffs, beneath the collectors directly on the roofing surface.

For the intermittent flame test, the test deck is subjected to a luminous gas flame--having a temperature of 1400° $\pm$ 50° F (760° $\pm$ 28° C) for class A and B and 1300° $\pm$ 50° F (704° $\pm$ 28° C) for class C--approximately the width of the test deck, which uniformly bathes the surface. The flame is applied intermittently for specified periods with specified time intervals between flame applications, as indicated below.

Method of Test	Flame on (min)	Flame off (min)	No. of Test Cycles
Class A	2	2	15
Class B	2	2	8
Class C	1	2	3

For the spread of flame test the same type of luminous gas flame used for the intermittent flame tests, including flame temperature, is applied continuously for 10 minutes for classes A and B and 4 minutes for class C.

The conditions for classification for the burning brand and the intermittent flame test are the same. During the test, no glowing or flaming brands from the roof deck or covering shall continue to glow after reaching the floor, the roof deck shall not be exposed, and there shall be no flaming on the underside of the roof deck. For the spread of flame test, the classification conditions are that flaming shall not have spread beyond 6 feet (1.8 m) for class A, 8 feet (2.4 m) for class B, and 13 feet (4.0 m) for class C. The burning brand test and the intermittent flame test are primarily intended to determine if the fire will penetrate the roof deck and if the roof will spread burning brands. The spread of flame test provides a measure of surface flame travel.

3. TEST RESULTS

The test results obtained are summarized in the sections which follow. Only a few repeat tests were conducted on selected collectors because of the exploratory nature of the test program; however, for rating purposes, ASTM E 108 requires replicate tests for each of the tests discussed below. Complete tabulations of the test results obtained are presented in the Appendix to this report. Materials, collector designs, and mounting configurations other than those tested may yield different results.

3.1 Burning Brand Test

Tests were conducted with class A, B, and C brands using a variety of collector types and mounting configurations. With one exception, no sustained ignitions were obtained with class C brands. This size brand had no visible effect on either tempered or annealed glass. When class C brands were placed directly on fiberglass reinforced plastic (FRP) surfaces (tests 10,15), small flames were observed on the FRP directly adjacent to some of the brands, and a small area of the FRP was blackened; but, in no case did flames continue after the brand burned out. The

same phenomena were observed when C brands were placed on a FRP surface with no slope and no wind (test 23). When Class C brands were placed on shingles with either an FRP collector (test 12) or a sheet of plywood (test 22) mounted 4 inches (10.2 cm) above the shingles the brands did not ignite either the shingles, or the FRP or the plywood above the shingles. The class C brands did ignite the one collector with acrylic glazing tested (test 30). The acrylic burned both up the collector with the wind, and down the collector against the wind, resulting in deformation of the collector. The collector insulation became involved in the fire, following which burning plastic dripped out of the collector.

Both class A and B brands readily ignited the FRP glazings on both collectors tested (tests 11, 16), but their absorber plates prevented penetration fire through those collectors. Flames were observed in the air passages of the air collector tested (test 16). The flames on the FRP spread only in the direction of the wind and not opposed to it. One test conducted with a class A brand resulted in the shattering of the tempered glass glazing (test 9); however, the absorber plate prevented the fire from penetrating the collector. One test with a class B brand resulted in the breaking of the annealed glass glazing used (test 31); but, unlike the tempered glass which fractured into small pieces, the annealed glass broke into large pieces, some of which slid off the collector. The absorber plate again prevented the fire from penetrating the collector. The influence of a class B brand on tempered glass was not investigated. In one test, a class B brand was placed on the shingled roof deck beneath a collector with a FRP case mounted on standoffs (test 13). The brand ignited the collector case and the shingles, and the test was terminated prematurely due to the excessive size of the fire. It should be noted that the deck used was covered with class C shingles. In another test using class C brands (test 12), neither the shingles nor the FRP case of the collector ignited.

3.2 Intermittent Flame Test

Class C intermittent flame tests were conducted with three collectors having cases constructed of FRP, wood, and aluminum respectively, mounted one foot back from the leading edge of the test deck (tests 1, 2, 4, 6). In all tests, neither the shingles nor the collector were ignited.

3.3 Spread of Flame Test

The majority of the tests conducted were spread of flame tests. These included calibration tests on roof decks with no collectors and tests with collectors mounted directly on the roof, integral as the roof, and at a number of standoff distances from the roof. Spread of flame test results are summarized in Table 3. The calibration tests were used to compare the results from the two test laboratories and also as a baseline to assess the influence of solar collectors. At the first laboratory, the flame had spread 5 1/2 feet (1.7 m) after four minutes during one test and 6 1/2 feet (2.0 m) during a second test on a different day. At the second laboratory, the flame had spread 8 feet (2.4 m) in each of two tests conducted on different days.

The results of spread of flame tests on collectors can be categorized as spread along combustible glazings and spread under collectors mounted on standoffs. No variation in the spread of flame test results as a function of collector insulation type was observed. In the majority of tests, the collectors were mounted one foot back from the leading edge of the roof deck and the shingles on the leading edge of the test deck were the first material to ignite. In all cases where the collector had a FRP glazing, the FRP ignited and flames traveled rapidly to the end of the collector, usually in less than one minute. When the roof deck was longer than the collector and smoke did not obscure observation, the flames from the FRP glazing were observed to ignite the shingles beyond the collector. A single test was conducted in which acrylic glazing was exposed to the spread of flame test (test 26). In this test, the glazing began to sag into the collector when exposed to the test flame, and it took almost four minutes for it to ignite. Once ignited, flames reached the end of the collector in approximately three minutes.

The spread of flame under collectors was primarily a function of the separation or standoff distance between the collector and the roof covering. Although the collectors with combustible backs certainly contributed fuel to the fire, the rate of flame travel between the roof deck and the back of the collectors was not significantly different from those constructed of steel or aluminum. Generally when a collector was mounted 4 inches (10.2 cm) above and parallel to the roof, flames would extend beyond the end of the 13-foot (4.0-m) deck within the four minute test period (tests 5, 7, 8, 17, 19, 24, 25, 33, 39, 42). The single test conducted with 6-inch (15.2-cm) standoffs also resulted in flame spread beyond the end of the test deck within 4 minutes (test 27). A number of tests were conducted with 2-inch (5.1-cm) standoffs (tests 34, 35, 38, 40, 43). In some of these, the flame spread to the end of the test deck within four minutes (tests 34, 38). In others, the flames did not spread beyond the end of the collector (tests 35, 40, 43). This appeared to result from the metal collector bottom deflecting towards the roof deck as a result of the heat and blocking flame travel beneath the collector. This phenomenon was also noticed in one of the 4-inch (10.2-cm) standoff tests (test 25).

Additional tests were conducted with collectors with noncombustible backs at smaller standoff distances: 9/16 inch (1.4 cm) (test 44), 1 inch (2.5 cm) (tests 47, 49), and 1 9/16 inches (4.0 cm) (test 50). In these tests, the flames did not travel beyond the end of the collector. One test was conducted in which an aluminum case collector was mounted at an angle to the roof surface: 2 inches (5.1 cm) above the roof at the lower end (towards the flames) and 24 inches (61 cm) above at the upper end (test 28). The collector was approximately 8 feet (2.4 m) long forming a 13° angle with the roof. After the four-minute test period, the flames had spread approximately 1 foot (30.5 cm) under the collector. The test was allowed to continue; and, at 5 1/2 minutes, the flames completely filled the area between the test deck and the collector back and spread to the end of the 13-foot (4.0-m) test deck. This compared to a spread of 8 feet (2.4 m) in 5 1/2 minutes on a calibration deck with no collector.

A test was conducted with a collector having wood sides and a plywood back mounted above the roof on two 3/4-inch (1.9-cm) thick wood strips which served as standoffs (test 45). These strips were equal in length to the width of the collector and were mounted perpendicular to the direction of flame travel in the test 28 inches (71 cm) from each end. During the four-minute test, flame travel under the collector was limited to the leading 28 inches (71 cm) up to the wood strip. Flaming was also noted on the leading edge of the collector and along the sides back to the location of this wood strip.

4. DISCUSSION OF RESULTS

4.1 Burning Brand Test

The results of this test program indicated that the burning brand test may be applied to solar collectors with only minor modifications. Brands could be placed both on top of the collector and on the roof covering below a stand-off-mounted collector. Metal absorber plates of the thickness commonly used in solar collectors act as a barrier to the penetration of flames from brands as large as class A. However, heat conducted through the absorber plate could conceivably ignite certain types of organic insulation materials in direct contact with the absorber. The test results indicated that with a collector mounted on 4-inch (10.2-cm) standoffs, neither the collector nor the asphalt shingles of the type tested will be affected by class C brands placed on a roof covering similar to that tested. Class A and B brands are likely to cause ignition on such stand-off-type collectors when combustible cases are used and will result in significant burning of class C asphalt shingles similar to those tested. It is not clear that A or B size brands are likely to be blown under collectors mounted on standoffs and thus represent a significant hazard. This may be more significant with rack-mounted collectors where the space under the collector is larger and more accessible. Where collectors with untempered glass glazing were tested, large pieces of glass fell from the collector during the test. ASTM E 108 does not address this potential type of hazard.

4.2 Intermittent Flame Test

The limited test results obtained indicated that the spread of flame test and the burning brand test are more severe test conditions than the intermittent flame test when evaluating roof-mounted solar collectors. Collectors which met these requirements for the burning brand and spread of flame tests also met those for the intermittent flame test.

4.3 Spread of Flame Tests

The presence of the collector and its associated mounting configurations, appeared to have the most impact on the spread of flame test. While it is impractical to test collectors in all possible mounting configurations, the test results indicated there may not be a single worst case mounting configuration. The selection of a mounting

configuration becomes a function of the philosophy of the test method with regard to simulating use conditions.

Collectors mounted on standoffs greater than approximately 1 1/2 inches (3.8 cm) above a class C roof covering will result in flame travel under the collectors greater than that allowed by the test criteria regardless of collector construction. The presence of any type of collector case material (either combustible or noncombustible) directly above the roof covering appears to increase or enhance radiative heat transfer to the roof covering and channel the wind towards the roof, thus increasing the rate of flame travel. If the collector is mounted far enough above the roof, these effects will be reduced although the separation distance required for this to occur was not examined as part of this program. The greatest standoff distance tested in which the collector was parallel to the roof was 6 inches (15.2 cm) and the enhancement effect was substantial at this distance. The use of blocking strips for fire stopping under the collectors may be the only method by which the test criteria can be met for standoff distances greater than approximately 1 1/2 inches (3.8 cm). However, blocking may present other problems, such as the trapping of moisture, leaves, and snow. Additional testing is necessary to fully define the effect of standoff distance and collector tilt angle on flame travel.

The set back distance between the leading edge of the roof deck and the leading edge of the collector also needs to be examined in more detail. For most of the tests, a 1-foot (30-cm) set back distance was used. This distance appears to be suitable for examining flame spread under the collector. It generally allows the roof deck to be the first material ignited and the flame to spread under the collector. In order to test for spread of flame directly on the glazing, the collector should be mounted with the glazing flush and even with the cornice, with no set back distance, otherwise, the collector may block the flame. Collector size as it relates to the size of the test decks used and the size of the test apparatus also needs to be examined.

Collectors with combustible glazing could provide a path for rapid flame spread from one area of a roof to another area. Building codes do not clearly address such flame travel when a considerable portion of it takes place on a material mounted above the roof covering. In addition to testing the glazing as part of the collector, testing separately for flame spread on the glazing material in the E 108 apparatus appears desirable. This is especially true in the case of thermoplastic materials, such as the acrylic tested in this program which sagged into the collector case and was shielded from the test flame for a period of time. This resulted in a time delay in the fire involvement of the cover. However, once it became involved the spread of flame was greater than that observed for the roof covering when tested alone.

Small-scale tests such as ASTM D 635 [7] Test for Flammability of Self Supporting Plastics have been incorporated, for purposes of certification, in the roofing requirements for plastic glazings of some model building codes. Several organic cover materials exhibited very rapid spread of flame in the present test program. In view of the large expanses of combustible glazings which may be used in solar energy systems, the use such small-scale tests and their correlation with the ASTM E 108 test needs to be examined in more detail.

The presence of roof-mounted solar collectors can significantly increase the spread of flame across a roof. However, it is not known whether or not this will result in a substantial increase in hazard by reducing the fire integrity of the roof deck itself. The conditions of classification of ASTM E 108 need to be carefully examined to ensure that they address this potential increase in hazard. The possibility of fire penetration into the building air duct systems from the burning of glazings on air collectors also requires further investigation. In addition, careful documentation of fire occurrences with roof-mounted collectors is required to determine the extent of increased hazard.

5. ACKNOWLEDGEMENTS

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[7] Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Self-supporting Plastics in a Horizontal Position, ASTM No. D 635-77, American Society for Testing and Materials, Philadelphia, PA 19103 (1977).

TABLE 1. Test Collector Description

COLLECTOR CODE	MATERIALS					APPROXIMATE DIMENSIONS LENGTH X WIDTH X DEPTH
	CASE SIDES	CASE BACK	GLAZING	INSULATION	ABSORBER	
29-L	Aluminum	Aluminum	Glass (tempered)	Foam plastic[1]	Aluminum	102 x 36 x 3 1/2 in (259 x 127 x 17.7 cm)
32-L	Wood	Plywood	FRP[2]	Fiberglass	Aluminum	120 x 48 x 5 in (305 x 127 x 17.7 cm)
41-L	Wood	Plywood	Double Glass (tempered)	Urethane foam	Copper	94 x 36 x 3 3/8 in (239 x 91 x 8.6 cm)
43-L	Molded FRP	Molded FRP	FRP	Urethane foam	Copper	96 x 36 x 5 3/4 in (244 x 91 x 14.6 cm)
45-1	Aluminum	Aluminum	FRP	Foam plastic	Aluminum	118 x 37 3/4 x 3 in (300 x 96 x 7.6 cm)
46-L	Aluminum	Hardboard	Glass (tempered)	Isocyanurate foam	Copper	93 x 35 x 3 1/2 in (236 x 89 x 8.9 cm)
54-L	Wood	Plywood	Glass (annealed)	Fiberglass	Aluminum	99 x 49 3/4 x 3 1/2 in (251 x 126 x 8.9 cm)
103-L	Aluminum	Aluminum	Acrylic	Polystyrene (loose fill)	Aluminum	96 x 48 x 7 1/2 in (244 x 122 x 19.1 cm)
108-L	Steel	Steel	FRP	Fiberglass	Steel	86 1/2 x 40 x 3 in (220 x 102 x 7.6 cm)
126-L	Aluminum	Aluminum	Glass (tempered)	Fiberglass	Copper	77 x 35 x 5 in (196 x 89 x 12.7 cm)
78-A	Aluminum	Aluminum	FRP	None	Aluminum	196 3/4 x 24 x 7 1/4 in (500 x 61 x 18.4 cm)

[1] Rigid foam plastic, type unknown

[2] FRP - glass fiber reinforced plastic

Table 2
Summary of Test Configurations

Collector Code	Test Type[1]	Test No.	Test Lab.[2]	Mounting[3]
--	SF	21	UL	Calibration deck only
--	SF	29	UL	Calibration deck only
--	SF	36	AETL	Calibration deck only
--	SF	48	AETL	Calibration deck only
--	C Brand	22	UL	4-inch (10.2-cm) standoff, brand under plywood (0 incline)
29L	SF	35	AETL	2-inch (5.1-cm) standoff
29L	SF	43	AETL	2-inch (5.1-cm) standoff
32L	SF	46	AETL	Direct
32L	SF	47	AETL	1-inch (2.5-cm) standoff
41L	IF	4	UL	4-inch (10.2-cm) standoff
41L	SF	5	UL	4-inch (10.2-cm) standoff
41L	SF	17	UL	4-inch (10.2-cm) standoff
43L	IF	1	UL	4-inch (10.2-cm) standoff
43L	IF	2	UL	Direct
43L	SF	3	UL	Direct
43L	C Brand	10	UL	Direct (2 in 12 incline)
43L	A Brand	11	UL	Direct (2 in 12 incline)
43L	C Brand	12	UL	4-inch (10.2-cm) standoff, brand under (2 in 12 incline)
43L	B Brand	13	UL	4-inch (10.2-cm) standoff, brand under (2 in 12 incline)
43L	SF	20	UL	Direct
43L	C Brand	23	UL	Direct (0 incline)(no wind)
45L	SF	37	AETL	Direct
45L	SF	38	AETL	2-inch (5.1-cm) standoff
45L	SF	39	AETL	4-inch (10.2-cm) standoff
46L	IF	6	UL	4-inch (10.2-cm) standoff
46L	SF	7	UL	4-inch (10.2-cm) standoff
46L	SF	19	UL	4-inch (10.2-cm) standoff
54L	B Brand	31	AETL	Direct
54L	C Brand	32	AETL	Direct
54L	SF	45	AETL	3/4-inch (1.9-cm) standoff
78A	B Brand	14	UL	No deck (integral) (2 in 12 incline)
78A	C Brand	15	UL	No deck (integral) (2 in 12 incline)
78A	A Brand	16	UL	No deck (integral) (2 in 12 incline)
78A	SF	18	UL	No deck (integral)
103L	SF	26	UL	No deck (integral)
103L	SF	27	UL	6-inch (14.2-cm) standoff
103L	SF	28	UL	2 - 24-inch (5.1 - 61.0-cm) rack (4 in 12 deck incline and 22 in 93 collector incline to deck)
103L	C Brand	30	UL	Direct (3 in 12 incline)
108L	SF	40	AETL	2-inch (5.1-cm) standoff
108L	SF	41	AETL	Direct
108L	SF	42	AETL	4-inch (10.2-cm) standoff
126L	SF	8	UL	4-inch (10.2-cm) standoff
126L	A Brand	9	UL	Direct
126L	SF	24	UL	4-inch (10.2-cm) standoff
126L	SF	25	UL	4-inch (10.2-cm) standoff
126L	SF	33	AETL	4-inch (10.2-cm) standoff
126L	SF	34	AETL	2-inch (5.1-cm) standoff
126L	SF	44	AETL	9/16-inch (1.4-cm) standoff
126L	SF	49	AETL	1-inch (2.5-cm) standoff
126L	SF	50	AETL	1-9/16-inch (4.0-cm) standoff

[1] Test Type: IF - Intermittent Flame; SF - Spread of Flame; A Brand - Class A Burning Brand; B Brand - Class B Burning Brand; C Brand - Class C Burning Brand

[2] Test Laboratory: AETL - Approved Engineering Test Laboratories; UL - Underwriters Laboratories

[3] All inclines 5 in 12 except as noted

TABLE 3

Summary of Spread of Flame Test Results[1]

Collector Code	Spread of Flame Test Results
29L	With 2-in (5.1-cm) standoffs, attached flames of 6 ft (1.8 m) on deck under collector; intermittent flames to the end of the 10-ft (3.0-m) deck.
32L	Flames extended up entire length of the cover in approximately 1 minute; flames extended beyond cover. Flames extended 3 ft (0.9) m) on deck under collector with 1-in (2.5 cm) standoff. Intermittent unattached flames traveled up between collector and deck.
41L	With 4-in (10.2-cm) standoffs attached flames traveled on deck under collector to the end of the test deck; Flames beyond the 13-ft (4.0-m) deck. Back of collector ignited.
43L	In two tests the collector was mounted direct on the deck. In first case, flames traveled up entire cover in 4 min; in second case, where asphalt ignition was delayed for unexplained reasons to 4 min 17 sec; flaming up entire cover took an additional 1 min, 8 sec from the time of ignition of shingles.
45L	Attached flames extended up entire length of cover in less than 2 min for both direct mount and 2-in (5.1-cm) standoffs. Flames extended beyond the cover. Tests terminated prematurely due to intense flames and smoke.
46L	With 4-in (10.2-cm) standoffs attached flames traveled on deck under collector to end of test deck. Flames beyond end of 13-ft (4.0-m) deck. Back of collector ignited.
54L	Flames traveled approximately 3 ft (0.9 m) on deck under collector. 3/4-in (1.9-cm) wood standoffs perpendicular to direction of flame travel prevented further flame spread. Front edge and bottom of collector up to first standoff ignited.

[1] Test times were 4 minutes unless otherwise specified.

Attached flames are above the surface and appear to be connected to the surface. Unattached flames are above the surface but do not appear to be connected to the surface.

TABLE 3 (Continued)

Collector Code	Spread of Flame Test Results
103L	Cover deformed into collector case and was partially shielded from the ignition flame. Test was conducted without roof deck. Cover ignited at 3 min, 46 sec, at 4 minutes test flame was turned off. At 4 min, 32 sec attached flames reached the end of the collector. With 6 in (15.2 cm) standoffs attached flames traveled on deck under collector to the end of the 13.5-ft (4.1-m) test deck. Flames extended beyond end of deck. With leading edge of collector 2 in (5.1 cm) and trailing edge 24 in (61 cm) above roof deck, attached flames traveled 1 ft (0.3 m) on cover and 2 ft (0.6 m) on deck under collector in 4 minutes. At 4 min, 27 sec attached flames extended up the entire length of the cover and under the collector to the end of the 13.5-ft (4.1-m) test deck.
108L	In all tests attached flames traveled up the entire length of the cover in less than 1 minute. With 2-in (5.1-cm) standoffs attached flames traveled 6 ft (1.8 m) on the deck under collector in 4 minutes. With 4-in (10.2-cm) standoffs, attached flames traveled on the deck under collector to the end of the deck. In test with collector direct on deck flames from cover ignited shingles beyond collector.
126L	With 9/16-in (1.4-cm), 1-in (2.5-cm) and 1 9/16-in (4.0-cm) standoffs flames traveled less than 4 ft (1.2 m) on deck under collector in 4 minutes. With 2-in (5.1-cm) and 4-in (10.2-cm) standoffs attached flames traveled on deck under collector to end of deck and flames extended beyond deck, with two exceptions. In the first, the collector bottom deflected, blocking flames and air flow and in the second, there was an unexplained delay in ignition of shingles as compared to ignition time in almost all other tests.
78A	Attached flames traveled the 14 ft (4.9 m) length of the cover in 1 min, 21 sec. Flames extended beyond cover.
Calibration Decks	Attached flames traveled 4.4 ft (1.7 m) 6.5 ft. (2.0 m) and 8 ft (2.4 m) in 4 minutes. In one case where the test was extended to 10 minutes, flames traveled 11.5 ft (3.5 m).

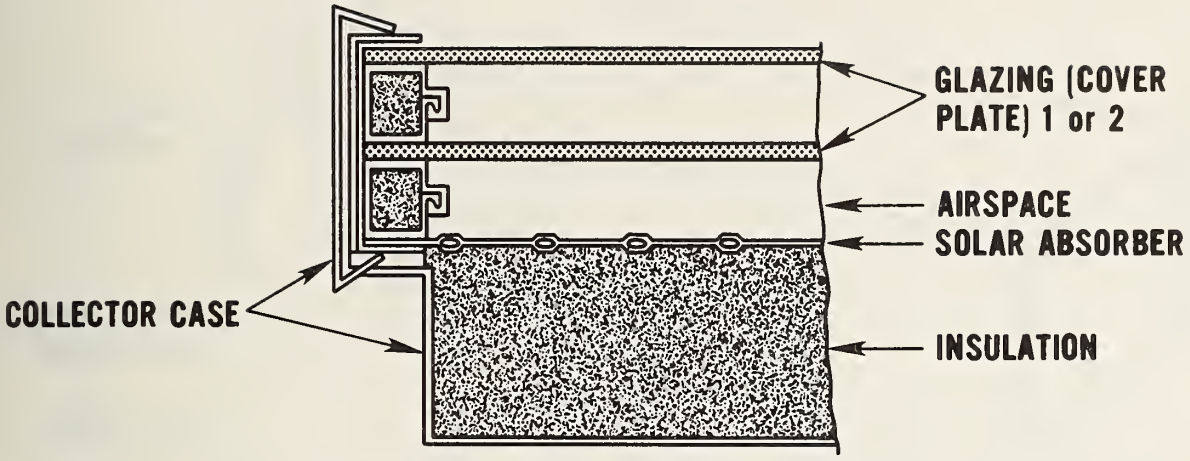

Figure 1. Cross Section of Typical Flat Plate Solar Collector

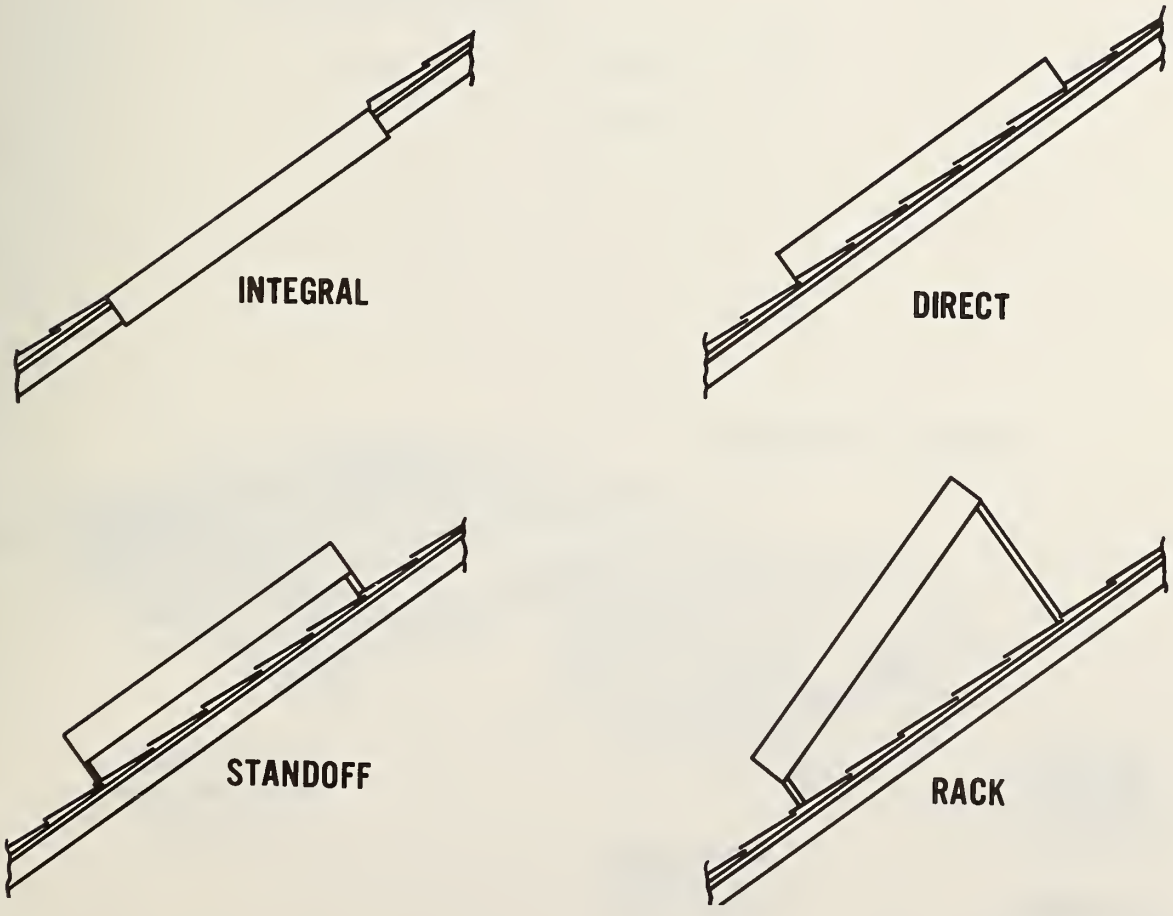

Figure 2. Collector Mounting Configurations

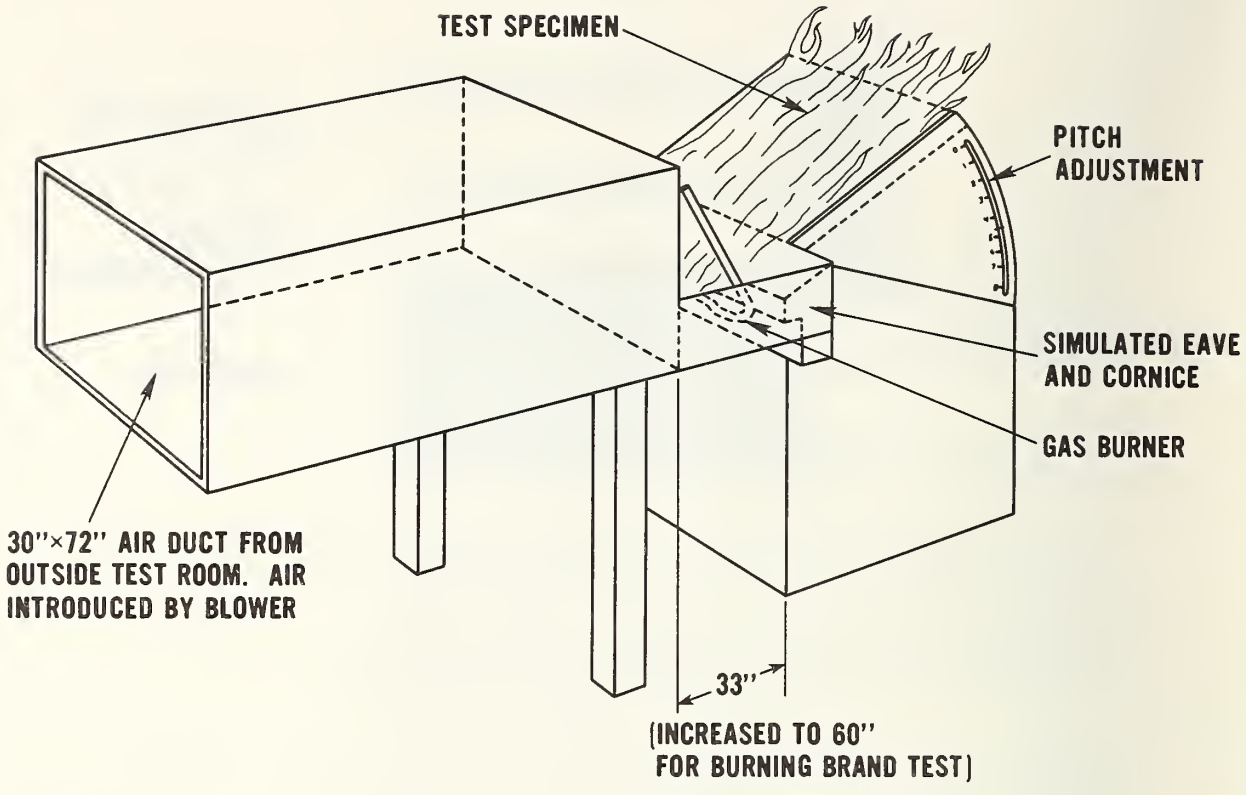

Figure 3. Schematic for Fire Test Apparatus

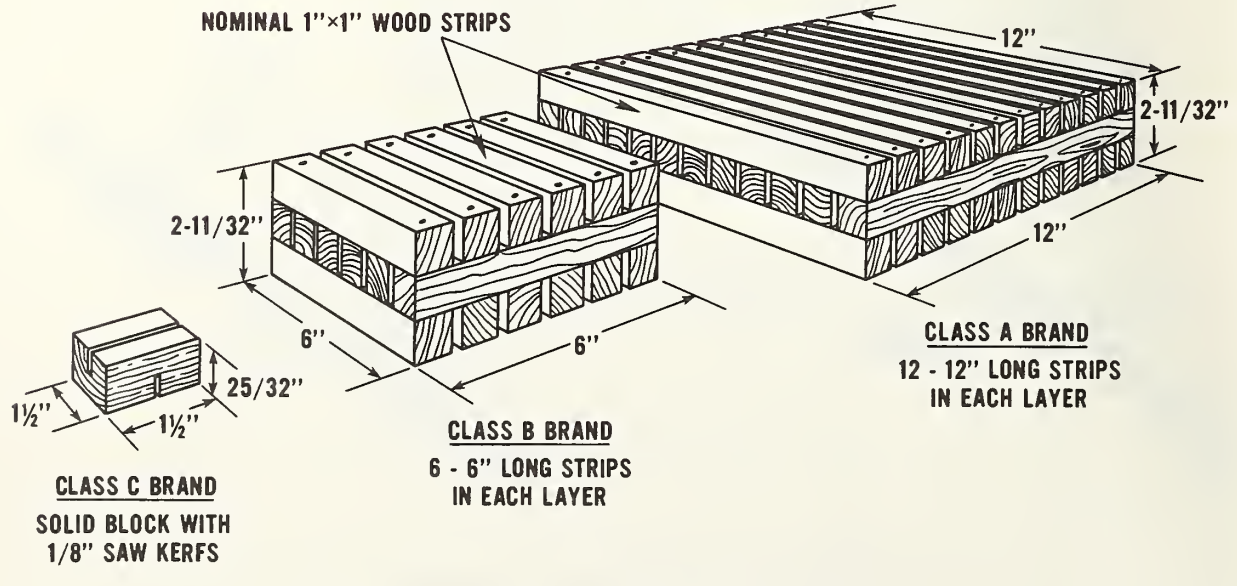

Figure 4. Fire Brands for Class A, B, and C Tests

APPENDIX

Test Number: 1

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: 43L

Test Type: Intermittent Flame

Test Class: C

Size of Deck: 3 1/3 ft (1.0 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: 4 in (10.2 cm) above and parallel to the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:01	Flame on.
0:42	Cover warping, asphalt melting on shingles, no ignition.
1:00	Flame off - no change.
3:00	Flame on.
4:00	Flame off - no ignition of shingles on collector, some warping of cover.
6:00	Flame on.
7:00	Flame off - no ignition of shingles or collector; test terminated.

SUMMARY COMMENTS

No ignition of shingles or collector.

Test Number: 2

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: 43L - (Same collector and deck as used in Test Number 1)

Test Type: Intermittent Flame

Test Class: C

Size of Deck: 3 1/3 ft (1.0 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: Leading edge direct on roof deck and trailing edge 4 in (10.2 cm) above deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:01	Flame on.
1:00	Flame off - no ignition of shingles or collector.
3:00	Flame on.
4:00	Flame off - no change.
6:00	Flame on.
7:00	Flame off - no ignition of shingles or collector; test terminated.

SUMMARY COMMENTS

No ignition of shingles or collector.

Test Number: 3

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: 43L (same collector and deck as used in Tests 1 and 2)

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/3 ft (1.0 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: Leading edge direct on roof deck and trailing edge 4 in (10.2 cm) above deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:01	Flame on.
2:15	Shingles ignited; blistering of plastic base at leading edge.
3:12	Collector base ignited at leading edge.
3:20	Collector cover ignited.
3:48	Flame spread along the entire length of the collector cover.
4:00	Test terminated.

SUMMARY COMMENTS

Collector cover burned to the end of its approximate 8 ft (2.4 m) length in 3 min, 48 sec. Flames extended beyond the end of the collector. The shingles were not affected beyond the leading edge of the collector which was in contact with the shingles at that point.

Test Number: 4

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: 41L

Test Type: Intermittent Flame

Test Class: C

Size of Deck: 1 1/3 ft (1.0 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: 4 in (10.2 cm) above and parallel to the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:01	Flame on.
1:00	Flame off - no ignition of shingles or collector - some melting of asphalt.
3:00	Flame on.
4:00	Flame off - slight discoloration of wood frame, melting of asphalt, no ignition.
6:00	Flame on.
7:00	Flame off - no ignition of shingles or collector; test terminated.

SUMMARY COMMENTS

No ignition of shingles or collector.

Test Number: 5

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: 41L (same collector and deck as used in Test 4)

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/3 ft (1.0 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: 4 in (10.2 cm) above and parallel to the roof deck set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:01	Flame on.
1:00	No ignition; some melting of asphalt.
2:08	Ignition of shingles.
2:30	Flame spread 2 ft (0.6 m) on shingles.
2:32	Ignition of bottom of collector.
2:40	Flame extending over the entire length of deck.
2:50	Test terminated.
3:00	Collector and deck still flaming.
3:25	Test terminated.

SUMMARY COMMENTS

Intensive flaming between the bottom of the collector and shingles.

Test Number: 6

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: 46L

Test Type: Intermittent Flame

Test Class: C

Size of Deck: 3 1/3 ft (1.0 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: 4 in (10.2 cm) above and parallel to the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:01	Flame on.
1:00	Flame off - no ignition of shingles or collector; some melting of asphalt.
3:00	Flame on.
4:00	Flame off; no ignition.
6:00	Flame on.
7:00	Flame off; no ignition of shingles or collector; test terminated.

SUMMARY COMMENTS

No ignition of shingles or collector.

Test Number: 7

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: 46L (same collector and deck as used in Test 6)

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/3 ft (1.0 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: 4 in (10.2 cm) above and parallel to the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:01	Flame on.
2:08	Ignition of shingles.
2:36	Flame spread 3 ft (0.9 m) on shingles.
2:56	Ignition of bottom of collector.
3:04	Flame extending over the entire length of deck; test terminated.

SUMMARY COMMENTS

Intensive flaming between the bottom of the collector and shingles.

Test Number: 8

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: 126L

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/3 ft (1.0 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: 4 in (10.2 cm) above and parallel to the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:01	Flame on.
1:58	Bottom of collector distorting downward.
4:00	No ignition; some melting of asphalt.
NOTE:	At end of standard 4 min flame exposure, test was continued at request of NBS personnel.
4:40	Ignition of shingles.
5:12	Flame spread 2 ft (0.6 m) on shingles
5:30	Flame spread 3 ft (0.9 m) on shingles.
5:50	Flame spread 5 ft (1.5 m) on shingles and paint burning on bottom of collector.
6:00	Flame extending over entire length of deck; test terminated.

SUMMARY COMMENTS

Ignition of the shingles did not occur until after the normal 4 minute test period.

Note: Also, see results of Test No. 24.

Test Number: 9

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: 126L

Test Type: Burning Brand

Test Class: A

Size of Deck: 3 1/3 ft (1.0 m) by 4 1/3 ft (1.3 m)

Incline of Deck: 5 in 12

Collector Mounting: Direct on roof deck, no set back from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:20	Brand in place on collector cover 24 in (61 cm) from the leading edge and midway between the collector sides.
0:58	Cover bowing upward in brand area.
2:45	Approximate 3/4 in (1.9 cm) upward bow in cover at brand.
3:36	1/4 of brand consumed.
5:07	1/2 of brand consumed.
7:40	3/4 of brand consumed.
8:25	Glass cover crazed but remained in place without any flying glass; brand still in place on top of the absorber.
11:30	7/8 of brand consumed.
13:00	Only small embers of brand remaining.
16:58	Brand out; test terminated.

SUMMARY COMMENTS

Brand did not penetrate the collector absorber, no ignition of the shingles.

Test Number: 10

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: 43L

Test Type: Burning Brand

Test Class: C

Size of Deck: 3 1/3 ft (1.0 m) by 4 1/3 ft (1.3 m)

Incline of Deck: 2 in 12

Collector Mounting: Direct on roof deck, no set back from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
NOTE:	All brands were placed on the collector cover 24 in (61 cm) from the leading edge with approximately 5 in (13 cm) spacing between each brand.
2:13	First brand in place.
4:06	Second brand in place.
5:11	Third brand in place.
6:46	Flame out on first brand.
6:58	Flame out on third brand.
7:12	Fourth brand in place.
8:10	Fifth brand in place.
NOTE:	Due to action of brands on collector, NBS personnel directed that additional brands need not be placed on collector.
10:00	Light flaming at cover in the immediate area of Brands 2, 4, 5.
19:00	All flaming out; test terminated.

SUMMARY COMMENTS

Brands did not penetrate the collector cover, no ignition of the shingles.

Test Number: 11

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: 43L (same collector and deck as used in Test 10)

Test Type: Burning Brand

Test Class: A

Size of Deck: 3 1/3 ft (1.0 m) by 4 1/3 ft (1.3 m)

Incline of Deck: 2 in 12

Collector Mounting: Direct on roof deck, no set back from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:14	Brand in place on collector cover 44 in (112 cm) from the leading edge and midway between the collector sides.
0:48	Cover ignited.
1:08	Flame spread to the trailing end of the cover.
2:35	Cover still burning to the end of the collector and spreading laterally out to both sides. Flame also spread approximately 6 in (15 cm) toward the leading edge.
3:51	Flame subsiding.
4:46	Cover burning only at three isolated areas other than at the brand.
5:22	Brand 1/4 consumed. Flame out at all but one location other than brand area.
7:12	Flaming confined to brand area only.
7:32	Brand 1/2 consumed.
15:00	Brand 7/8 consumed with no flaming; just glowing embers.
21:38	Brand out; test terminated.

SUMMARY COMMENTS

Brand did not penetrate the collector absorber , no ignition of the shingles.

Test Number: 12

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: 43L (same collector and deck as used in Tests 10 and 11)

Test Type: Burning Brand (Brands under collector)

Test Class: C

Size of Deck: 3 1/3 ft (1.0 m) by 4 1/3 ft (1.3 m)

Incline of Deck: 2 in 12

Collector Mounting: 4 in (10 cm) above and parallel to the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
NOTE:	All brands were placed on the shingles under the collector in three rows located 22 in (56 cm), 28 in (71 cm), and 34 in (86 cm) from the leading end of the deck with approximately 5 in (13 cm) between each brand.
1:00	First brand in place.
3:45	Second brand in place.
4:13	Third brand in place.
5:08	Fourth brand in place.
6:10	Fifth brand in place.
7:20	Sixth brand in place.
8:16	Seventh brand in place.
9:13	Eighth brand in place.
10:11	Ninth brand in place.
11:21	Tenth brand in place.
12:14	Eleventh brand in place.

Test Number: 12 (continued)

NOTE:	Due to negligible action of brands, NBS personnel directed that additional brands need not be placed on shingles.
12:10	All brands out; test terminated.

SUMMARY COMMENTS

Brands did not ignite the shingles or the collector above.

Test Number: 13

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: 43L (same collector and deck as used in Tests 10, 11, and 12)

Test Type: Burning Brand (brand under collector)

Test Class: B

Size of Deck: 3 1/3 ft (1.0 m) by 4 1/3 ft (1.3 m)

Incline of Deck: 2 in 12

Collector Mounting: 4 in (10.2 cm) above and parallel to the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
NOTE:	The brand was placed on the shingles under the collector at approximately 24 in (61 cm) from the leading edge of the deck and midway between the collector sides.
0:10	Brand in place.
0:57	Bottom of collector distorting downward; asphalt melting on shingles.
1:10	Ignition of shingles.
1:46	Flame spread 1 ft (0.3 m) on shingles.
1:58	Ignition of bottom of collector.
2:18	Flames extending past end of collector and both sides.
2:20	Test terminated.

SUMMARY COMMENTS

Class B brand ignited the Class C shingles. The collector was then ignited.

Test Number: 14

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: 78A

Test Type: Burning Brand

Test Class: B

Size of Deck: No deck used.

Incline of Deck: Collector incline of 2 in 12.

Collector Mounting: Collector mounted in place of the roof deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:15	Brand in place on collector cover 36 in (91 cm) from the leading edge.
0:28	Ignition of cover.
0:48	Flame spread 1 1/2 ft (0.5 m) on cover.
1:04	Flame spread 2 1/2 ft (0.8 m) on cover.
1:29	Flame spread 7 ft (2.1 m) on cover.
1:39	Flame spread to end of collector cover.
1:55	The flame was extinguished with a hose except in the immediate area of the brand.
3:00	Flaming on the cover at the brand area only. Some burning inside the collector apparently on the inside surface of the cover.
4:30	Light flaming at brand only.
5:15	Brand 1/2 consumed.
6:30	Brand 3/4 consumed.
10:08	Brand out; test terminated.

SUMMARY COMMENTS

Flaming on both the inside and outside of the collector cover. Brand did not penetrate the absorber plate.

Test Number: 15

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: 78A (same collector as used in Test 14)

Test Type: Burning Brand

Test Class: C

Size of Deck: No deck used.

Incline of Deck: Collector incline of 2 in 12.

Collector Mounting: Collector mounted in place of the roof deck.

TEST OBSERVATIONS

Time, Min:Sec	Observations
NOTE:	Three Class C brands were placed on the cover 1 ft (30 cm) from the leading edge of the collector in an area unaffected by the previous test. The brands were approximately 5 in (13 cm) apart.
2:05	First brand in place.
2:15	Second brand in place.
2:25	Third brand in place.
NOTE:	Due to little action of brands on collector, NBS personnel directed that additional brands need not be placed on collector.
2:58	Ignition of cover at brand one.
3:30	Flame spread of approximately 5 in (13 cm) on cover at brand one.
5:04	Brand one flaming out.
5:09	Small area of flaming out at brand one.
9:00	All brands out; test terminated.

SUMMARY COMMENTS

Brands did not penetrate the collector cover.

Test Number: 16

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: 78A (same collector as used in Tests 14 and 15)

Test Type: Burning Brand

Test Class: A

Size of Deck: No deck used.

Incline of Deck: Collector incline of 2 in 12.

Collector Mounting: Collector mounted in place of the roof deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:12	Brand in place on collector cover 10 in (25 cm) from the leading edge and midway between the collector sides.
0:21	Ignition of cover.
1:31	Flaming inside collector.
3:00	Brand 1/4 consumed, flame at brand area only.
4:34	Brand 1/2 consumed.
6:00	Large holes burned through cover in brand area.
8:00	Brand 3/4 consumed.
13:35	Remainder of brand burned through cover and resting on absorber plate.
17:58	Brand out; test terminated.

SUMMARY COMMENTS

Flaming on both the inside and outside of the collector cover. Brand did not penetrate the absorber plate.

Test Number: 17

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: 41L

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/3 ft (1.0 m) by 13 ft (4.0 m)

Incline of Deck: 5 in 12

Collector Mounting: 4 in (10.2 cm) above and parallel to the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:01	Flame on.
1:11	Melting of asphalt.
2:43	Ignition of shingles.
3:12	Ignition of bottom of collector.
3:24	Flame spread to end of collector.
3:45	Flame spread to end of deck.
3:50	Test terminated.

SUMMARY COMMENTS

Intensive flaming between the bottom of the collector and shingles. Flames extended beyond the end of the deck.

Test Number: 18

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: 78A

Test Type: Spread of Flame

Test Class: C

Size of Deck: No deck used.

Incline of Deck: Collector incline of 5 in 12.

Collector Mounting: Collector mounted in place of the roof deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:01	Flame on.
0:07	Distortion of cover up to first cover support.
0:30	Distortion of cover up to second cover support.
0:40	Ignition of cover.
0:50	Flame spread 4 ft (1.2 m) on cover.
0:57	Flame spread 6 ft (1.8 m) on cover.
1:04	Flame spread 8 ft (2.4 m) on cover.
1:21	Flame spread to end of collector.
1:24	Test terminated.

SUMMARY COMMENTS

Flame spread rapidly on collector glazing. Flames extended beyond the end of the collector.

Test Number: 19

Test Laboratory: Underwriters Laboratories Inc.

Collector Codes: 46L

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/3 ft (1.0 m) by 13 ft (4.0 m)

Incline of Deck: 5 in 12

Collector Mounting: 4 in (10.2 cm) above and parallel to the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:01	Flame on.
0:45	Melting of asphalt.
1:54	Ignition of shingles.
2:29	Flame spread 1 ft (0.3 m) on shingles.
2:49	Ignition of bottom of collector.
3:03	Flame spread to end of collector.
3:14	Flame spread to end of deck.
3:26	Test terminated.

SUMMARY COMMENTS

Intensive flaming between the bottom of the collector and shingles.

Test Number: 20

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: 43L

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/3 ft (1.0 m) by 4 1/3 ft (1.3 m)

Incline of Deck: 5 in 12

Collector Mounting: Direct on roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:01	Flame on.
0:21	Distortion of cover to first cover support.
0:49	Melting of asphalt.
1:21	Distortion of cover to second cover support.
2:05	Distortion of cover to third cover support.
4:00	No further action. End of standard 4 min. Flame exposure, test continued at request of NBS personnel.
4:17	Ignition of shingles.
4:45	Ignition of end of collector.
5:04	Ignition of cover.
5:25	Flame spread to end of collector.
5:27	Test terminated.

SUMMARY COMMENTS

Cover did not ignite during the 4 minute test period. Once ignited flames spread rapidly on the cover. Narrow areas on each side of the cover next to the edge of the collector were not involved in flaming.

Test Number: 21

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: None

Test Type: Spread of Flame Calibration Test

Test Class: C

Size of Deck: 3 1/3 ft (1.0 m) by 13 ft (4.0 m)

Incline of Deck: 5 in 12

Collector Mounting: N. A.

TEST OBSERVATIONS

Time, Min:Sec	Observations
0:01	Flame on.
0:32	Melting of asphalt.
1:42	Ignition of shingles.
2:10	Flame spread 2 ft (0.6 m) on shingles.
2:18	3 ft (0.9 m) spread.
2:35	4 ft (1.2 m) spread.
3:11	4 1/2 ft (1.4 m) spread.
3:19	5 ft (1.5 m) spread.
3:49	6 ft (1.8 m) spread.
4:00	6 1/2 ft (2.0 m) spread; test terminated.

SUMMARY COMMENTS

Meets Class C requirements.

Test Number: 22

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: None (plywood used to simulate a collector, same deck used as in Test 20)

Test Type: Burning Brand (no wind)

Test Class: C

Size of Deck: 3 1/3 ft (1.0 m) by 13 ft (4.0 m)

Incline of Deck: 0

Collector Mounting: Plywood mounted 4 in (10.2 cm) above and parallel to the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
2:37	First brand in place on the shingles under the plywood.
3:06	Second brand in place.
3:29	Third brand in place.
4:03	Fourth brand in place.
NOTE:	Due to little action of brands, NBS personnel directed that additional brands need not be placed on shingles.
4:41	Flame out on first brand.
5:02	Flame out on second brand.
5:48	Flame out on third brand.
7:49	Flame out on fourth brand; test terminated.

SUMMARY COMMENTS

No ignition of shingles or plywood.

Test Number: 23

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: 43L (same collector and deck used as in Test 20)

Test Type: Burning Brand (no wind)

Test Class: C

Size of Deck: 3 1/3 ft (1.0 m) by 13 ft (4.0 m)

Incline of Deck: 0

Collector Mounting: Direct on the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
NOTE:	This test was conducted without any air flow to study the effect of no air current on the brands. The brands were placed at random locations on the cover of the collector trying to avoid areas affected by the previous test.
2:00	First brand in place.
2:12	Second brand in place.
3:07	Third brand in place.
3:10	Fourth brand in place.
4:02	Fifth and sixth brands in place.
NOTE:	Due to little action of brands on collector, NBS personnel directed that additional brands need not be placed on collector.
4:20	Ignition of cover at first and second brands, limited burning in the brand area.
5:30	Ignition of cover at fourth brand.
6:17	All flame out at fourth brand, cover still lightly burning at brands one and two.
6:58	Flaming of brands one and two out, cover still lightly burning in area of brands one and two.
7:05	Flaming of brand three out.
7:19	Flaming of brand six out.

Test Number: 23 (continued)

TEST OBSERVATIONS

Time, Min:Sec	Observation
9:00	Limited burning of the cover at brands one and two, brand five still lightly burning.
10:40	All flaming out at brand two.
10:48	Flame out at brand five.
14:21	All flame out at brand one; test terminated.

SUMMARY COMMENTS

Burning of the cover was limited to small areas directly adjacent to the brands. Continued burning of cover at brands one and two may have been caused by placement of these brands in areas that may have been affected by previous test.

Test Number: 24

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: 126L

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/3 ft (1.0 m) by 13 ft (4.0 m)

Incline of Deck: 5 in 12

Collector Mounting: 4 in (10.2 cm) above and parallel to the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:01	Flame on.
0:36	Melting of asphalt.
1:40	Ignition of shingles.
2:18	Flame spread 2 ft (0.6 m) on shingles.
2:36	Flame spread 3 ft (0.9 m) on shingles, bowing of collector bottom downward.
2:54	Flame spread 4 ft (1.2 m) on shingles.
2:59	Flame spread to end of collector in the space between the shingles and the collector, paint burning on bottom of collector.
3:41	Flame spread to end of deck.
3:44	Test terminated.

SUMMARY COMMENTS

Intensive flaming between the bottom of the collector and shingles.

NOTE: Variation in results of Test Nos. 8 and 24 (with same model collector, same mounting, and same test conditions) apparently due to unexplained delay in ignition time of shingles in Test No. 8 as compared with ignition time in Test No. 24 and other spread of flame tests.

Test Number: 25

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: 126L

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/3 ft (1.0 m) by 13 ft (4.0 m)

Incline of Deck: 5 in 12

Collector Mounting: 4 in (10.2 cm) above and parallel to the roof deck, no set back from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:01	Flame on.
0:37	Melting of asphalt.
2:38	Ignition of shingles.
2:58	Flame spread 2 ft (0.6 m) on shingles.
3:08	Flame spread to end of collector.
3:23	Flame spread 8 ft (2.4 m), bottom of collector bowed down to such a degree that it is restricting the air flow and flame progression.
4:00	Flame spread 8 1/2 ft (2.6 m) at end of standard 4 min test.
5:00	Test terminated.

SUMMARY COMMENTS

The excessive distortion of the bottom of the collector retarded the spread of flame.

Test Number: 26

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: 103L

Test Type: Spread of Flame

Test Class: C

Size of Deck: No deck used.

Incline of Deck: Collector incline of 5 in 12.

Collector Mounting: Collector mounted in place of the roof deck leading edge of the collector approximately 3 in (7.6 cm) above the cornice.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:01	Flame on.
0:24	Distortion of cover.
1:40	Cover distortion over 1/2 of collector.
2:27	Cover deforming down into the collector - supported by absorber plate - small holes developing in cover.
3:30	Smoke inside collector.
3:46	Ignition of cover.
4:00	Test flame off - cover still burning, approximately 4 - 6 in (10 - 15 cm) spread.
5:13	Flame spread 2 ft (0.6 m) on cover - flame spreading laterally toward sides of collector.
6:10	Flame spread 4 ft (1.2 m) on cover - flaming on inside of cover.
6:32	Flame spread to end of collector.
6:40	Test terminated.

SUMMARY COMMENTS

At the end of the 4 minute test period, the flame spread was approximately 4 to 6 in (10.2 to 15.2 cm). The test flame was terminated at 4 minutes with the burning of the cover progressing to the end of the collector at 6 min, 32 sec.

Test Number: 27

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: 103L

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/3 ft (1.0 m) by 13 1/2 ft (4.1 m)

Incline of Deck: 5 in 12

Collector Mounting: 6 in (15.4 cm) above and parallel to the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:01	Flame on.
0:44	Shingle edges melting.
1:13	Melting of asphalt.
2.11	Ignition of shingles.
2:32	Flame spread 1 1/2 ft (0.5 m) on shingles, bottom of collector bowing downward.
2:54	Flame spread 4 ft (1.2 m) on shingles.
3:08	Flame spread 6 ft (1.8 m) on shingles.
3:16	Flame spread to end of collector.
3:26	Flame spread to end of deck.
3:56	Bottom of collector bowing down.
4:11	Test terminated.

SUMMARY COMMENTS

The flame spread to the end of the test deck in 3 min, 26 sec. Intensive flaming between the bottom of the collector and shingles.

Test Number: 28

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: 103L

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/3 ft (1.0 m) by 13 1/2 ft (4.1 m)

Incline of Deck: 4 in 12

Collector Mounting: The leading edge of the collector mounted 2 in (5.1 cm) and the trailing edge 24 in (61 cm) above the roof deck, set back 1 ft (30 cm) from the leading edge of the deck. The trailing end was supported by nominal 2 x 4 inch lumber.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:01	Flame on.
0:44	Shingle edges melting.
1:10	Melting of asphalt - some distortion of cover.
2:21	Ignition of shingles.
3:18	Flame spread 1 1/2 ft (0.5 m) on shingles.
3:26	Ignition of cover.
3:53	Flame spread 2 ft (0.6 m) on shingles and 1 ft (0.3 m) on cover.
4:12	Flame spread 3 ft (0.9 m) on shingles.
4:31	Flame spread 6 ft (1.2 m) on shingles and 2 ft (0.6 m) on cover.
5:00	Flame spread 7 ft (2.1 m) on shingles and 6 ft (1.8 m) on cover.
5:27	Flame spread to end of cover and deck, test terminated.

SUMMARY COMMENTS

At the end of the 4 minute test period the flame spread was approximately 2 ft (61 cm) on the deck and 1 ft (30.5 cm) on the cover. At 5 min, 27 sec the flame spread to the end of the test deck and the cover.

Test Number: 29

Test Laboratory: Underwriters Laboratories Inc.

Collector Code: None

Test Type: Spread of Flame Calibration Test

Test Class: C

Size of Deck: 3 1/3 ft (1.0 m) by 13 1/2 ft (4.1 m)

Incline of Deck: 5 in 12

Collector Mounting: N. A.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:01	Flame on.
0:29	Shingle edges melting.
1:02	Melting of asphalt.
2:16	Ignition of shingles.
2:38	2 ft (0.6 m) spread.
3:06	3 ft (0.9 m) spread.
3:28	4 ft (1.2 m) spread.
3:48	5 ft (1.5 m) spread.
4:00	5 1/2 ft (1.7 m) spread - end of Class C test time.
4:12	6 ft (1.8 m) spread.
4:30	6 1/2 ft (2.0 m) spread.
4:43	7 ft (2.1 m) spread.
5:00	7 1/2 ft (2.3 m) spread.
5:35	8 ft (2.4 m) spread.
6:12	9 ft (2.7 m) spread.
8:15	11 ft (3.4 m) spread.
10:00	11 1/2 ft (3.5 m) spread; test terminated.

SUMMARY COMMENTS

Meets Class C requirements.

Test Number: 31

Test Laboratory: Approved Engineering Test Laboratories

Collector Code: 54L

Test Type: Burning Brand

Test Class: B

Size of Deck: 3 1/2 ft (1.1 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: Direct on deck, no set back from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
NOTE:	1 Class B Brand used.
0:00	Brand positioned on second cover glass panel from the leading edge of the collector.
0:10	Panel glass cracked.
0:30	Cover glass panel above brand broke.
0:55	Cover glass shattered in two sections.
7:50	Brand out; test terminated.

SUMMARY COMMENTS

The collector cover consisted of 4 equal annealed glass panels mounted perpendicular to the long axis of the collector. The brand resulted in breakage of two glass panels. Some pieces of the broken glass slid off the collector. The Brand did not penetrate the absorber plate.

Test Number: 32

Test Laboratory: Approved Engineering Test Laboratories

Collector Code: 54L (same collector and deck as used in Test 31)

Test Type: Burning Brand

Test Class: C

Size of Deck: 3 1/2 ft (1.1 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: Direct on roof deck, no set back from leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
NOTE:	Five Brands were placed on the first cover glass panel from the leading edge of the collector approximately 8 in (20 cm) on center. This panel was undamaged in the previous test.
0:00	First brand placed on cover.
1:00	Second brand placed on cover.
2:00	Third brand placed on cover.
3:00	Fourth brand placed on cover.
4:00	Fifth brand placed on cover.
13:39	All brands consumed, glass not broken, no apparent damage; test terminated.

SUMMARY COMMENTS

Class C brands had no apparent effect on the annealed glass used.

Test Number: 33

Test Laboratory: Approved Engineering Test Laboratories

Collector Code: 126L

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/2 ft (1.1 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: 4 in (10.2 cm) above and parallel to the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:00	Burner ignited.
0:50	Melting of asphalt.
1:01	Shingles ignited burning approximately 1 ft (0.3 m) up deck.
1:13	Shingles burning to 3 ft (0.9 m).
1:33	Shingles burning to 6 ft (1.8 m).
1:49	Shingles burning to 10 ft (3.1 m).
2:00	Flames to 3 ft (0.9 m) over end of deck. Collector did not ignite, cover glass broke during water spray at test termination.

SUMMARY COMMENTS

Intensive flaming between the bottom of the collector and shingles.

Test Number: 34

Test Laboratory: Approved Engineering Test Laboratories

Collector Code: 126L

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/2 ft (1.1 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: 2 in (5.1 m) above and parallel to the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:00	Burner ignition.
1:19	Shingles ignited.
1:41	Shingles burning approximately 1 ft (0.3 m) up deck.
1:58	Shingles burning approximately 3 ft (0.9 m) up deck, aluminum melting from lower forward edge of the collector.
2:10	Shingles burning approximately 7 ft (2.1 m) up deck.
2:43	Shingles burning approximately 8 ft (2.4 m) up deck.
2:59	Shingles burning approximately 10 ft (3.1 m) up deck, aluminum on collector melted approximately 1 ft (0.3 m) from the leading edge on underside and foam insulation burning.
3:25	Flames approximately 2 ft (0.6 m) over end of deck.
3:52	Flames approximately 4 ft (1.2 m) over end of deck.
4:16	Flames approximately 4 ft (1.2 m) over end of deck. Underside of collector burned through approximately 1 1/2 ft (0.5 m) from the leading edge. Water spray shattered glass and collector buckled at test termination.

SUMMARY COMMENTS

Intensive flaming between the bottom of the collector and shingles.

Test Number: 35

Test Laboratory: Approved Engineering Test Laboratories

Collector Code: 29L

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/2 ft (1.1 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: 2 in (5.1 cm) above and parallel to the roof deck set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:00	Burner ignition.
0:44	Melting of asphalt.
1:33	Shingles ignited.
1:55	Shingles burning to approximately 1 ft (0.3 m).
2:12	Shingles burning to approximately 2 ft (0.6 m).
2:20	Front edge of collector burning.
2:30	Glass in collector broke.
2:45	Shingles burning to approximately 3 ft (0.9 m).
3:00	Shingles burning to approximately 4 ft (1.2 m).
3:30	Shingles burning to approximately 6 ft (1.8 m).
4:00	Shingles burning to approximately 6 ft (1.8 m) beneath the collector; Intermittent flames to the end of the deck; test terminated.

SUMMARY COMMENTS

Flaming of the shingles under the collector. Shingles were not burning to the end of the roof deck.

Test Number: 36

Test Laboratory: Approved Engineering Test Laboratories

Collector Code: None

Test Type: Spread of Flame (Calibration Test)

Test Class: C

Size of Deck: 3 1/2 ft (1.1 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: N. A.

TEST OBSERVATIONS

Time, Min:Sec	Observations
0:00	Burner ignition
1:01	Melting of asphalt.
1:35	Shingles ignited.
1:55	Shingles burning to approximately 1 ft (0.3 m).
2:21	Shingles burning to approximately 4 ft (1.2 m).
2:42	Shingles burning to approximately 6 ft (1.8 m).
3:02	Shingles burning to approximately 6 1/2 ft (2.0 m).
3:31	Shingles burning to approximately 7 ft (2.1 m).
3:55	Shingles burning to approximately 8 ft (2.4 m).
4:00	Shingles burning to approximately 8 ft (2.4 m); test terminated.

SUMMARY COMMENTS

Meets Class C requirements.

Test Number: 37

Test Laboratory: Approved Engineering Test Laboratories

Collector Code: 45L

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/2 ft (1.1 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: Direct on the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:00	Ignition of burner
0:39	Melting of asphalt.
0:53	Shingles burning to approximately 1/2 ft (0.2 m), collector cover burning to approximately 2 ft (0.6 m).
1:35	Flames spread to end of collector cover 9 ft (2.7 m), shingles burning to 1 ft (0.3 m).
2:00	Flame extended beyond the end of the collector; test terminated.

SUMMARY COMMENTS

Flame spread rapidly on collector glazing.

Test Number: 38

Test Laboratory: Approved Engineering Test Laboratories

Collector Code: 45L

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/2 ft (1.1 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: 2 in (5.1 cm) above and parallel to the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:00	Burner ignition.
0:41	Collector cover ignited, shingles ignited.
1:00	Shingles burning to approximately 2 ft (0.6 m), collector cover burning to 5 ft (1.5 m).
1:24	Shingles burning to approximately 2 ft (0.6 m), collector cover burning to 10 ft (3.1 m).
1:55	Shingles burning to approximately 2 ft (0.6 m), Flames extended from the cover 3 ft (0.9 m) over the end of deck; test terminated.

SUMMARY COMMENTS

Flames spread rapidly on the collector glazing.

Test Number: 39

Test Laboratory: Approved Engineering Test Laboratories

Collector Code: 45L

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/2 ft (1.1 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: 2 in (10.2 mm) above and parallel to the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:00	Burner ignition.
0:40	Cover ignited.
1:15	Shingles ignited.
1:29	Cover burning to end of collector.
1:55	Shingles burning to 6 ft (1.8 m) beneath the collector.
2:00	Flames extended from the cover to 2 ft (0.6 m) over the end of the deck, shingles burning to approximately 7 ft (2.1 m); test terminated.

SUMMARY COMMENTS

Flame spread rapidly on the collector glazing. The bottom of the collector deflected and melted as a result of the intensive flaming under the collector.

Test Number: 40

Test Laboratory: Approved Engineering Test Laboratories

Collector Code: 108L

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/2 ft (1.1 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: 2 in (5.1 m) above and parallel to the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:00	Burner ignition.
0:29	Collector cover burning.
0:47	Collector cover burning to top of the collector.
1:00	Flames extended from the collector cover to 3 ft (0.9 m) beyond the end of the collector shingles.
1:52	Shingles ingited.
1:57	Shingles burning to approximately 3 1/2 ft (1.1 m) beneath the collector.
2:03	Shingles burning to approximately 4 ft (1.2 m).
2:40	Shingles burning to approximately 4 1/2 ft (1.4 m).
3:00	Shingles burning to approximately 5 ft (1.5 m).
4:00	Shingles burning to approximately 6 ft (1.8 m); test terminated.

SUMMARY COMMENTS

Flames spread rapidly on the collector glazing.

Test Number: 41

Test Laboratory: Approved Engineering Test Laboratories

Collector Code: 108L

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/2 ft (1.1 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: Direct on the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:00	Burner ignition.
0:22	Cover burning.
0:48	Cover burning to top of collector.
1:00	Flames from the cover extended approximately 3 ft (0.9 m) beyond the end of collector.
1:30	Shingles ignited at top of deck beyond the collector, shingles burning to 1 ft (0.3 m) at bottom of deck.
2:38	Burning of approximately 1 ft (0.3 m) of the shingles beyond the collector. Shingles burning up from bottom approximately 1 ft (0.3 m).
3:00	Flames on cover receded to approximately 4 ft (1.2 m)
4:00	Shingles burning top 1 ft (0.3 m), bottom 1 ft (0.3 m). Cover burning approximately 3 1/2 ft (1.1 m); test terminated.

SUMMARY COMMENTS

Flame spread rapidly on the collector glazing and ignited the shingles beyond the collector.

Test Number: 42

Test Laboratory: Approved Engineering Test Laboratories

Collector Code: 108L

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/2 ft (1.1 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: 4 in (10.2 cm) above and parallel to the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:00	Burner ignition.
0:40	Melting of asphalt, collector cover ignited.
1:00	Shingles ignited.
1:24	Shingles burning to approximately 3 ft (0.9 m).
1:51	Collector cover burning to end of collector.
2:18	Flames from the cover extended 2 ft (0.6 m) beyond the collector.
2:53	Shingles burning to approximately 5 ft (1.5 m) beneath the collector.
3:08	Shingles burning to approximately 6 ft (1.8 m), Flames extended from the cover approximately 5 ft (1.52 m) over end of deck. Shingles ignited at the top of the deck beyond the collector.
3:44	Conditions remained unchanged; test terminated.

SUMMARY COMMENTS

Flames spread rapidly on the collector glazing. Intensive flaming between the bottom of the collector and shingles.

Test Number: 43

Test Laboratory: Approved Engineering Test Laboratories

Collector Code: 29L

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/2 ft (1.1 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: 2 in (5.1 cm) above and parallel to the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:00	Burner ignition.
0:38	Melting of asphalt.
1:16	Shingles ignited.
1:34	Shingles burning to 1 ft (0.3 m).
1:49	Shingles burning to 3 ft (0.9 m).
1:58	Cover glass broke, and front edge of collector ignited.
2:50	Shingles burning to approximately 4 ft (1.2 m).
3:23	Shingles burning to approximately 5 ft (1.5 m).
3:38	Shingles burning to approximately 5 1/2 ft (1.7 m).
4:00	Shingles burning to approximately 6 ft (1.8 m); test terminated.

SUMMARY COMMENTS

Flaming of shingles under the collector, leading edge and bottom of the collector melted exposing the collector insulation to the flames. The same test conditions as Test 35.

Test Number: 44

Test Laboratory: Approved Engineering Test Laboratories

Collector Code: 126L (Collector used in prior test)

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/2 ft (1.1 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: 9/16 in (1.4 cm) above and parallel to the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:00	Burner ignition.
0:55	Melting of asphalt.
1:40	Shingles ignited.
1:57	Shingles burning to approximately 1 ft (0.3 m).
2:38	Shingles burning to approximately 1 1/2 ft (0.5 m).
3:19	Shingles burning to approximately 2 ft (0.6 m).
3:59	Shingles burning to approximately 3 ft (0.9 m); test terminated.

SUMMARY COMMENTS

The 9/16 in (1.4 cm) separation between the collector and the roof prevented extensive flaming under the collector.

Test Number: 45

Test Laboratory: Approved Engineering Test Laboratories

Collector Code: 54L

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/2 ft (1.1 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: 3/4 in (1.9 cm) above and parallel to the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
NOTE:	Collector mounted on 3/4 in (19 cm) thick wood strips perpendicular to the long axis of the test deck located 28 1/4 in (72 cm) and 80 1/4 in (2.04 m) from the leading edge of the collector.
0:00	Burner ignition.
0:19	Leading edge of collector case ignited.
0:41	Melting of asphalt, panel glass broke.
0:54	Shingles burning to approximately 1 ft (0.3 m).
1:53	Shingles burning to approximately 1 1/2 ft (0.5 m).
2:51	Shingles burning to approximately 2 ft (0.6 m).
3:16	Shingles burning to approximately 2 1/2 ft (0.8 m).
4:01	Shingles burning to approximately 2 1/2 ft (0.8 m) beneath the collector. Front edge of collector totally in flame; test terminated.

SUMMARY COMMENTS

The wood strips on which the collector was mounted blocked the flame spread between the collector and the roof.

Test Number: 46

Test Laboratory: Approved Engineering Test Laboratories

Collector Code: 32L

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/2 ft (1.1 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: Direct on roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:00	Burner ignition.
0:19	Collector cover ignited.
0:36	Flames from the collector cover extended approximately 1 ft (0.3 m) beyond end of collector.
1:33	Shingles burning to approximately 1 ft (0.3 m).
1:58	Sides of collector burning to approximately 4 ft (1.2 m).
2:40	Flames receding to approximately 3 ft (0.3 m) on cover, sides burning to 4 1/2 ft (1.4 m).
3:12	Cover burning to approximately 3 ft (0.9 m). Sides to approximately 4 1/2 ft (1.4 m). Shingles burning to approximately 1 1/2 ft (0.5 m). Test terminated.

SUMMARY COMMENTS

Flame spread rapidly on the collector glazing.

Test Number: 47

Test Laboratory: Approved Engineering Test Laboratories

Collector Code: 32L

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/2 ft (1.1 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: 1 in (2.5 cm) above and parallel to the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:00	Burner ignition.
0:20	Collector cover ignited.
0:33	Bottom of collector ignited, melting of asphalt.
0:54	Flaming to the end of the collector cover.
1:17	Shingles burning to approximately 1 ft (30 cm).
1:55	Shingles burning to approximately 2 ft (0.5 m).
2:12	Shingles burning to approximately 2 1/2 ft (0.8 m).
2:30	Flames on cover receded to approximately 3 ft (0.9 m).
3:00	Shingles and bottom of collector burning to approximately 3 ft (0.9 m).
3:38	Shingles and bottom of collector burning to approximately 3 ft (0.9 m). Flames intermittently out upper end of collector.
4:00	Test terminated.

SUMMARY COMMENTS

Flame spread rapidly on the collector glazing.

Test Number: 48

Test Laboratory: Approved Engineering Test Laboratories

Collector Code: None

Test Type: Spread of Flame Calibration Test

Test Class: C

Size of Deck: 3 1/2 ft (1.1 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: N. A.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:00	Burner ignition.
0:28	Melting of asphalt.
0:59	Shingles ignited.
1:38	Shingles burning to approximately 4 ft (1.2 m).
2:05	Shingles burning to approximately 4 1/2 ft (1.4 m).
2:24	Shingles burning to approximately 5 ft (1.5 m).
2:56	Shingles burning to approximately 6 ft (1.8 m).
3:23	Shingles burning to approximately 6 1/2 ft (2.0 m).
3:39	Shingles burning to approximately 7 1/2 ft (2.3 m).
4:00	Shingles burning to approximately 8 ft (2.4 m); test terminated.

SUMMARY COMMENTS

Meets Class C requirements.

Test Number: 49

Test Laboratory: Approved Engineering Test Laboratories

Collector Code: 126L (collector used in prior test)

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/2 ft (1.1 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: 1 in (2.5 cm) above and parallel to the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:00	Burner ignition.
0:28	Melting of asphalt.
1:00	Shingles ignited.
1:19	Shingles burning to approximately 1 ft (0.3 m).
2:09	Shingles burning to approximately 1 1/2 ft (0.5 m).
3:07	Shingles burning to approximately 2 ft (0.6 m).
3:38	Shingles burning to approximately 2 1/2 ft (0.8 m).
4:00	Shingles burning to approximately 3 ft (0.9 m); test terminated.

SUMMARY COMMENTS

The 1 in (2.5 cm) separation between the collector and the roof prevented extensige flaming under the collector.

Test Number: 50

Test Laboratory: Approved Engineering Test Laboratories

Collector Code: 126L (collector used in prior test)

Test Type: Spread of Flame

Test Class: C

Size of Deck: 3 1/2 ft (1.1 m) by 10 ft (3.0 m)

Incline of Deck: 5 in 12

Collector Mounting: 1 9/16 in (4.0 cm) above and parallel to the roof deck, set back 1 ft (30 cm) from the leading edge of the deck.

TEST OBSERVATIONS

Time, Min:Sec	Observation
0:00	Burner ignition.
0:24	Melting of asphalt.
0:59	Shingles ignited.
1:09	Shingles burning to approximately 1 ft (0.3 m).
1:59	Shingles burning to approximately 2 ft (0.6 m).
2:38	Shingles burning to approximately 3 ft (0.9 m).
3:27	Shingles burning to approximately 3 1/2 ft (1.1 m).
3:51	Shingles burning to approximately 4 ft (1.2 m), collector restraining wires broke and the collector slid down the roof deck; test terminated.

SUMMARY COMMENTS

The 1 9/16 in (4.0 cm) separation between the collector and the roof prevented extensive flaming under the collector.

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5. AUTHOR(S)

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6. PERFORMING ORGANIZATION (If joint or other than NBS, see instructions)

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10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

A study was undertaken to investigate the use of ASTM E 108 (NFPA 256, UL 790), Fire Tests of Roof Coverings, for testing roof-mounted solar energy collectors. The ASTM E 108 test method is commonly referenced in building codes as the procedure for determining the fire characteristics of roof coverings. To date, no data have been available regarding the influence of solar collectors on the fire characteristics of roof coverings or on collectors used as roof coverings. This study focused primarily on class C intermittent flame, spread of flame, and burning brand tests, although several class A and B burning brand tests were conducted. The collectors studied were commercially available and constructed with a broad variety of glazing, casing, and insulation materials representative of those commonly in use. The collectors were tested on sloped, asphalt shingled roofs with three types of mountings: integrally as the roof, directly on the roof covering, and on standoffs above the roof covering. Data are presented showing the results of the testing conducted. An evaluation of the testing procedures as they apply to roof-mounted solar collectors is given.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

Fire tests; roofing fire resistance; roofing fire tests; solar collectors

13. AVAILABILITY

☒ Unlimited

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